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Bio-efficacy of Seed Priming with Fungicides against major Soil Borne Diseases of Maize

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ABSTRACT
Field experiments were conducted to evaluate the bio-efficacy of fungicides (Carbendazim 25% + Mancozeb 50% WS, Carbendazim 50 WP, Mancozeb 75 WP and Carboxin 37.5% + Thiram 37.5% WS) against the seed rot and seedling blight of maize at Research Farm, Zonal Agricultural Research Station, Jhabua (MP). All the fungicides were found significantly effective against the seed rot and seedling blight compared to control. The maximum seed germination (86.98 and 86.32% in kharif and rabi, respectively), shoot length (32.76 and 38.30 cm in kharif and rabi, respectively), root length (4.79 and 5.12 cm in kharif and rabi, respectively) and seedling vigour index (3254.8 in kharif and 3748.0 in rabi) were recorded on Carbendazim 25% + Mancozeb 50% WS @ 35 g/kg seeds (T_3) followed by Carbendazim 25% + Mancozeb 50% WS @ 3.0 g/kg seeds (T_2). While the lowest values of these parameters were in control. Similarly, lowest % disease incidences of seed rot (9.08 and 8.0% in respective seasons) and seedling blight (5.81 and 4.11%) was recorded with Carbendazim 25% + Mancozeb 50% WS @ 35 g/kg seeds followed by Carbendazim 25% + Mancozeb 50% WS @ 30 g/kg seeds. Yield attributes, yields and economics of maize also significantly influenced by various fungicides. Significantly higher grain yield of 2795 kg/ha and stover yield of 3860 kg/ha was recorded in Carbendazim 25% + Mancozeb 50% WS @ 35 g/kg seeds and which was on par with Carbendazim 25% + Mancozeb 50% WS @ 30 g/kg seeds. Maximum gross returns of Rs. 47914, net returns of Rs. 36615 and B:C ratio of 2.60 were also recorded with the seed priming with Carbendazim 25% + Mancozeb 50% WS @ 35 g/kg seeds.

Keywords
Maize, Seed rot, Seedling blight, Yields, Carbendazim, Mancozeb

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INTRODUCTION

Maize (*Zea mays* L.) was introduced to India from America at the beginning of 17^{th} century (Singh *et al*, 2018). Its ranks third as a food-grain crop after wheat and rice and it is not only as a cereal but also as vegetable, fodder crop and industrial crops (Singh *et al*, 2017) and (Kumawat *et al*, 2020) . It is called as queen of the cereals because highest productivity among the cereal crops (Kumar *et al*, 2017). Madhya Pradesh is the second major maize producing states among the country (Kumawat *et al*, 2019). In India, kharif maize is cultivated in 7.47 Mha with production of 17.85 Mt and productivity of 2391 kg/ha. While in rabi, it is cultivated in 1.75 Mha with production of 7.28 Mt and productivity of 4164 kg/ha. The Karnataka is the leading state which covered 3.73 Mt followed by Madhya Pradesh with production of 3.68 Mt (Anonymous, 2018). Wet and cool soil temperature (less than 50 to 55^0 F) can delay seed germination and emergence and predispose maize seedling to disease. Seedling become more vulnerable to infection the longer a seed is in the ground before emergence and the more stress germinating corn endures. When soil conditions are favourable for germination and used a broad-spectrum fungicides seed treatment can minimize the risk of seeding diseases of maize. In field conditions diagnosis of seedling diseases can be difficult because multiple pathogens are often involved and symptoms can appear similar. Several common soil borne fungi such as Fusarium, Penicillium, Pythium and Rhizoctonia are often isolated from infected seedings and roots of maize (Anonymous, 2015) . Seed treatment with fungicides protect the seed from infection by seed borne and soil borne pathogens, enables the seed to germinate and establish as a healthy seedling (Henis and Chet, 1975) and (Windels, 1981). Seed treatment is therefore a routine practice to ensure good emergence and better crop stand (Nene and Thapliyal, 1979) and (Ramos and Ribeiro, 1993).

MATERIALS AND METHODS

The field experiment as carried out during kharif 2017 and rabi 2017-18 at Research Farm, Zonal Agricultural Research Station, Jhabua to identify suitable fungicides for the control of soil borne diseases of maize under Jhabua Hill of Madhya Pradesh. The maize cultivar JVM-421 was sown in randomized block design with a spacing of 60 x 25 cm with three replications the details of the treatments given in Table 1.

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Fungicides were applied as wet seed treatment by mixing the test quantity of fungicide with requisite quantity of water (10 ml/kg seeds). Requisite quantity of water with the fungicide mixed in container drop by drop till the slurry becomes like runny mud then maize seeds were added to the slurry and covered with container then swirled and rolled the seed for uniform coating with chemical on seeds. Separate containers were used for different treatments. Required quantity of maize seed in each treatment for three replications was dressed with fungicide at a time. The treated maize seeds with respective fungicides were sown in the replicated plots and standard agronomic practices were adopted for both the seasons. The plots were inspected regularly to see the germination and the final percentage of germination of maize seeds was recorded for each treatment on 10^{th} day after sowing based on the formula suggested by Anonymous (1999).

$$Germination\ \% = \frac{No.\ of\ germinated\ seedling}{Total\ no.\ of\ seed\ sown\ in\ that\ plot} \times 100$$

Seedling vigor was measured at 30 days after sowing (DAS) of crop by standard formula given by International seed Testing Association (ISTA, 1985).

Vigor Index= (Root length + Shoot length) × Germination %

Scoring of soil borne diseases like seed rot and seedling blight caused by various pathogens such like that Rhizoctonia sp., Macrophomina sp., Pythium sp. Fusarium sp. was recorded separately and efficacy of molecule in controlling of these diseases were observed in each replicated plot at 30 DAS and per cent disease incidence were observed and calculated based on following formula:

$$PDI = \frac{No.\ of\ affected\ seedlings}{Total\ no.\ of\ seedlings\ observed} \times 100$$

Root length : Ten normal seedlings were selected randomly in each treatment from all the replications on eighth day from germination test. The root length was measured from the tip of the primary root to base of hypocotyls with the help of a scale and mean root length was expressed in centimetres.

Shoot length : The ten normal seedlings used for root length measurement were also used for the measurement of shoot length. The shoot length was measured form the tip of the primary leaf to the base of the hypocotyls and mean shoot length was expressed in centimetre.

The biometrical observations on crop growth parameters and yield attributes were recorded as per standard procedure. Data were recorded in terms of plant height, dry matter/plant, cob weight/cob, grain weight/cob, grain and stover yield and data of seasons were mean and analyzed. The net plot grain yield and stover yield was converted to in terms of q/ha. Net returns (₹/ha) was calculated by deducting cost of cultivation (₹/ha) from gross returns, while B:C ratio were worked out as a ratio of net return (₹/ha) to cost of cultivation (₹/ha). The data recorded were analysed as per analysis of variance technique for RBD.

Table 1: List of fungicides used in the study

Treatments	Doses in a.i. g/10 kg seed	Formulation (g/10 kg seed)
T_1=Carbendazim 25% + Mancozeb 50% WS	6.25+ 12.5	25
T_2=Carbendazim 25% + Mancozeb 50% WS	7.50+ 15.0	30
T_3=Carbendazim 25% + Mancozeb 50% WS	8.75+ 17.5	35
T_4=Carbendazim 50%WP	10.00	20
T_5=Mancozeb 75 %WP	18.78	25
T_6=Carboxin 37.5% + Thiram 37.5% WS	11.25+11.25	30
T_7=Control	-	-

RESULTS AND DISCUSSION

Bio-efficacy of new fungicides in mixture and alone on seed germination, shoot length and seedling vigor of maize

Significant differences in seed germination, root length, shoot length and seedling vigour was recorded due to seed treatment in maize (Table 2). Higher seed germination (86.98 and 86.32% in respective seasons) was recorded with Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds (T_3) and Carbendazim 25% + Mancozeb 50% WS @ 30 g/kg seed (85.85%) (T_2) which were significantly superior to rest of the treatments. Similarly, maximum shoot length of 32.76 and 38.30 cm were recorded under Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg (T_3) which was comparable with Carbendazim 25% + Mancozeb 50% WS @ 30 g/kg seed over the remaining treatments. Further table 1 showed that higher root length (4.79 cm in kharif and 5.12 cm in rabi) was observed with the seed treatment of Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seed which was at par with each other except control and Carbendazim 25% + Mancozeb 50% WS @ 25 g/10 kg seed. Effect of seed treatment on seedling vigour index differed significantly in all the fungicides treatments. The seeds treated with Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds (T_3) recorded significantly highest (3254.8 and 3748.0 in both the respective seasons) seedling vigour index followed by Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds. The lowest seedling vigour index (22.95.6 in kharif and 2561.4 in rabi) was recorded in untreated plots. The variation in seed germination percentage and root and shoot length might be due to chemical treatments keep the seed intact, as its acts as binding material.

Table 2: Bio-efficacy of new fungicides in mixture and alone on seed germination, shoot length and seedling vigor of maize

Treatments	Doses in a.i. g/10 kg seed	Seed germination (%)		Shoot length (cm)		Root length (cm)		Seedling vigour index	
		Kharif 2017	Rabi 2017-18	Kharif 2017	Rabi 2017-18	Kharif 2017	Rabi 2017-18	Kharif 2017	Rabi 2017-18
T_1=Carbendazim 25% + Mancozeb 50% WS	6.25+ 12.5	79.81	81.70	30.58	33.77	3.63	3.29	2730.3	3027.8
T_2=Carbendazim 25% + Mancozeb 50% WS	7.50+ 15.0	85.85	85.28	31.92	37.63	4.62	4.62	3136.9	3603.0
T_3=Carbendazim 25% + Mancozeb 50% WS	8.75+ 17.5	86.98	86.32	32.76	38.30	4.79	5.12	3254.8	3748.0
T_4=Carbendazim 50%WP	10.00	80.94	80.19	30.24	33.60	4.29	3.29	2794.8	2958.2
T_5=Mancozeb 75 %WP	18.78	77.55	78.58	29.90	33.26	4.13	2.96	2629.0	2846.1
T_6=Carboxin 37.5% + Thiram 37.5% WS	11.25+11.25	81.70	80.66	30.24	33.94	4.29	3.62	2821.1	3029.5
T_7=Control		75.94	76.85	27.65	30.97	2.58	2.36	2295.6	2561.4
CD (P=0.05)		3.41	3.35	1.28	3.64	0.92	1.00	–	–

It covers the minor cracks and aberration as the seed coat thus blocking the fungal invasion. It may also act as a physical barrier, which reduces leaching of inhibitors from seed covering and restricts oxygen movement and thus reducing the respiration of embryo thereby reducing the ageing effect on seed (Vanangamudi *et al*, 2003). In the present study also combi-fungicides besides being toxic to fungus might have acted as seed coat barriers inhibiting seed respiration resulting in delayed aging and improving germination per cent. This is in agreement with Anitha *et al* (2013) and Bana *et al* (2017).

Table 3: Bio-efficacy of new fungicides in mixture and alone on % incidence of soil borne diseases in maize

Treatments	Doses in a.i. g/10 kg seed	% incidence of seed rot		% incidence of seedling blight	
		Kharif 2017	Rabi 2017-18	Kharif 2017	Rabi 2017-18
T_1=Carbendazim 25% + Mancozeb 50% WS	6.25+ 12.5	10.05 (51.71)*	9.05 (53.47)*	6.59 (59.25)	5.05 (60.55)
T_2=Carbendazim 25% + Mancozeb 50% WS	7.50+ 15.0	9.56 (54.06)	8.36 (57.02)	6.28 (61.19)	4.49 (64.94)
T_3=Carbendazim 25% + Mancozeb 50% WS	8.75+ 17.5	9.08 (56.37)	8.00 (58.87)	5.81 (64.10)	4.11 (67.86)
T_4=Carbendazim 50%WP	10.00	10.58 (49.16)	9.54 (50.95)	6.62 (59.09)	6.73 (47.41)
T_5=Mancozeb 75 %WP	18.78	11.00 (47.12)	10.24 (47.35)	7.38 (54.39)	8.04 (37.18)
T_6=Carboxin 37.5% + Thiram 37.5% WS	11.25+11.25	10.69 (48.63)	9.80 (49.61)	6.59 (59.25)	5.61 (56.17)
T_7=Control		20.81 (0.00)	19.45 (0.00)	16.18 (0.00)	12.80 (0.00)
CD (P=0.05)		1.02	0.87	0.75	1.01

*Data inthe parenthesis showing percent increase of disease control over untreatedcontrol, SR= Seed rot, SB= Seedling blight

Bio-efficacy of new fungicides in mixture and alone on % incidence of soil borne diseases

The various fungicides used against seed rot of maize (Table 3) indicated that the lowest per cent disease incidence was recorded in Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seed (9.08 and 8.0%) and Carbendazim 25% + Mancozeb 50% WS @ 30 g/10 kg seed (9.56 and 8.36 %) as compared to control (20.81%). Both the above treatment combinations were control the disease 56.37 and 54.06 per cent in kharif and 58.87 and 57.02 per cent in rabi season, respectively over control. Similarly, results revealed that among the different treatments, seed treatments with Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seed recorded lowest % incidence of seedling blight (5.81% in kharif and 4.11% in rabi) which was statistically comparable to Carbendazim 25% + Mancozeb 50% WS @ 30 g/10 kg seed (6.28 and 4.49% in both respective seasons). Seed treatment with Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds recorded 64.10 per cent in kharif and 67.86 per cent in rabi reduction over control. Similar findings were also made by B Bhuvaneshwari *et al* (2014) and Kenganal and Nimbaragi (2017).

Table 4: Bio-efficacy of new fungicidesin mixture and alone on growth and yields of maize (mean data of two seasons)

Treatments	Doses in a.i. g/10 kg seed	Plant height (cm)	Dry matter /plant	Cob weight /cob	Grain weight /cob	Grain yield kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1=Carbendazim 25% + Mancozeb 50% WS		170.93	333.80	151.41	119.44	2394	3556	40.22	41790	28505	2.15
T_2=Carbendazim 25% + Mancozeb 50% WS	6.25+ 12.5	172.78	337.63	156.26	122.34	2650	3665	41.96	45445	32153	2.42
T_3=Carbendazim 25% + Mancozeb 50% WS	7.50+ 15.0	173.57	342.40	157.74	123.82	2795	3860	42.01	47914	34615	2.60
T_4=Carbendazim 50%WP	8.75+ 17.5	162.54	328.07	141.83	112.44	2325	3537	39.61	40837	27563	2.08
T_5=Mancozeb 75 %WP	10.00	161.53	325.23	141.74	113.13	2275	3387	40.17	39736	26469	1.99
T_6=Carboxin 37.5% + Thiram 37.5% WS	18.78	165.45	331.03	148.35	116.40	2363	3508	40.25	41238	27931	2.10
T_7=Control	11.25+11.25	155.75	301.19	134.05	107.33	2125	3195	40.01	37209	23959	1.81
CD (P=0.05)		9.85	18.44	8.17	11.31	158	265	NS	2096	2096	0.16

Bio-efficacy of new fungicides in mixture and alone on growth, yields and economics of maize (mean data of two seasons)

Mean data of two years are presented in Table 4 in respect to plant height, dry matter/plant, cob weight/cob and grain weight/cob differed significantly in all the fungicide treatments. Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 gave the highest plant height (173.57 cm), dry matter (342.40 g/plant), cob weight (157.74 g/cob) and grain weight (123.82 g/plant) which was at par with all the fungicidal treatments and significantly superior to control. Similarly, significantly highest grain yield (2795 kg/ha) and stover yield (3860 kg/ha) were recorded in Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds which was comparable with Carbendazim 25% + Mancozeb 50% WS @ 30 g/10 seeds. Whereas the lowest grain and stover yield (2125 and 3195 kg/ha) was recorded in absolute control plot. The harvest index did not influence by different fungicides in both the seasons. It was indicated that seed priming has differential influence on the allocation of assimilates between vegetative and reproductive organs. In general, crop yield depends on the accumulation of photo-assimilates during the growing period and the way they are partitioned between desired storage organs of plant. Bana *et al* (2017) and Gawade *et al* (2009) have also reported similar effect in different crops.

Economics

Table 5: Bio-efficacy of new fungicides in mixture and alone on growth, yields and economics of maize (mean data of two seasons)

Treatments	Doses in a.i. g/10 kg seed	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1=Carbendazim 25% + Mancozeb 50% WS		41790	28505	2.15
T_2=Carbendazim 25% + Mancozeb 50% WS	6.25+ 12.5	45445	32153	2.42
T_3=Carbendazim 25% + Mancozeb 50% WS	7.50+ 15.0	47914	34615	2.60
T_4=Carbendazim 50%WP	8.75+ 17.5	40837	27563	2.08
T_5=Mancozeb 75 %WP	10.00	39736	26469	1.99
T_6=Carboxin 37.5% + Thiram 37.5% WS	18.78	41238	27931	2.10
T_7=Control	11.25+11.25	37209	23959	1.81
CD (0.05)	-	2096	2096	0.16

The gross return, net returns and B:C ratio of maize significantly influenced by various fungicide treatments (Table 5). The maximum gross return of Rs. 47914/ha, net return of Rs. 34615 and B:C ratio (2.60) were recorded in seed priming with Carbendazim 25% + Mancozeb 50% WS @ 35 g/10 kg seeds followed by Carbendazim 25% + Mancozeb 50% WS @ 30 g/10 kg seeds. Whereas, minimum gross return (Rs. 37209) net returns (Rs. 23959/ha) and B:C ratio (1.81) was recorded in untreated control (Table 3). Similar results are also reported by Anitha *et al* (2013) and Kenganal and Nimbaragi (2017).

CONCLUSION

The results of this study indicated that seed priming with Carbendazim 25% + Mancozeb 50% WS (Sprint @ 35 g/10 kg seeds) is highly efficacious against seed rot and seedling blight and produced higher yields of maize.

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